

## SPECIFICATION

SYSTEM AND METHOD FOR SERVICE AND ADDRESS MANAGEMENT IN  
WLAN INTER-WORKING

5

## TECHNICAL FIELD

The invention pertains to the field of wireless data communication. More particularly, this invention relates to the address management in the wireless LAN (WLAN) environment for the mobile user to come from other networks. It could be used for the inter-working of the WLAN to the public radio networks, e.g. 3G networks, or WLANs using other radio technologies or in another administrative domain. The invention is used by the WLAN and the inter-worked network as well as the mobile terminal, for the address allocation, configuration, tunnelling set-up, etc, so that the mobile terminal is able to access services it subscribed to in the WLAN.

## 20 BACKGROUND ART

In WLAN inter-working, the terminal needs to be addressable so that it can access any service it subscribed to. When the services are delivered over IP, the terminal must be attached to a certain IP address. In the mobile world, the point of attachment of the terminal

changes frequently. It is highly possible that the terminal traverses a few domains during one active service session. To satisfy the requirements of terminal mobility, the address management mechanism is needed to configure 5 and update the terminal's address every time it changes the point of attachment.

Mobile IP is an open standard, defined by the Internet Engineering Task Force (IETF) (non-patent reference 1) (non-patent reference 2), that provide a 10 solution for the address management and traffic routing for the mobile terminals. It allows the user to remain reachable using the same address when roaming among different IP networks. Since the mobility is controlled at the IP level, it is not bound to the under lying link 15 layer technologies. Therefore, for terminals in the 3G cellular networks, or the Wireless LAN (e.g. 802.11 networks), same protocol stack could apply. With the merging of the access technologies, e.g. the inter-working of the WLAN and 3G cellular networks, this kind of 20 harmonized level solution is especially useful. In MobileIP, the address management is done over the IP connectivity. In case the IP connectivity is not available, it could not work. MobileIP also requires the terminal to own a Home Address, and know its Home Agent. 25 This might not be available in the inter-working scenarios,

e.g. when the terminal powers up in the foreign WLAN for the first time.

Mobile IPv6 draft has introduced a way of setting the home address of the mobile node (non-patent reference 5 2). The terminal would generate a care of address first, e.g. utilizing DHCPv6 (non-patent reference 3), and use this address to communicate with its home network to set up the final home address. In WLAN inter-working, this is not workable, since the mobile node's home network may not 10 be always reachable using the care of address obtained from the WLAN. Also, the multiple round-trip configuration procedure would be time consuming, and could not meet the expectation of the users.

The Diameter Mobile IPv6 Application (non-patent 15 reference 4) has presented a solution based on the AAA architecture for the address management for the Mobile IPv6. This solution has utilized the AAA servers and clients in the visited and home network to carry out the address updating and agent discovery. The mechanism 20 requires the mobile node to have local IP connectivity for the message exchange, e.g. able to listen for the Router Advertisement messages, and this is not always possible due to the foreign domain's local policy. Also, the scheme only caters for the situation where the address 25 belongs to the mobile terminal's home domain. In the WLAN

inter-working, the terminal would use address from another domain depending on the service it's accessing. This could not be supported in the scheme since it has not information of the service request of the terminal. This 5 scheme is designed for the Mobile IPv6 environment, and therefore could not work with terminals with no Mobile IP stack.

3GPP also has provided a solution, GTP (non-patent reference 5) for managing the terminal addressing and 10 tunnelling. GTP comprises two parts, GTP-C for control and GTP-U for user data traffic. GTP runs over UDP, and encapsulates the user data in the UDP packets. The GTP is designed for the GPRS (non-patent reference 6) network, and therefore depends heavily on the GPRS network's 15 features, e.g. GGSN, SGSN nodes. This makes it difficult to be deployed in the simple wireless access network (e.g. WLAN) .

(Non-patent reference 1) "IP mobility support for IPv4"

<http://www.ietf.org/rfc/rfc3344.txt>

20 (Non-patent reference 2) "Mobility support in IPv6"

<http://www.ietf.org/internet-drafts/draft-ietf-mobileip-ipv6-19.txt>

(Non-patent reference 3) "Dynamic Host Configuration  
Protocol for IPv6 (DHCPv6)"

25 <http://www.ietf.org/internet-drafts/draft-ietf-dhc->

dhcpv6-28.txt

(Non-patent reference 4) "Diameter Mobile IPv6 Application"

<http://www.ietf.org/internet-drafts/draft-le-aaa->

5 diameter-mobileip6-02.txt

(Non-patent reference 5) "GPRS Tunnelling Protocol (GTP) across the Gn and Gp Interface (Release 5)" 3GPP TS 29.060 V5.3.0 (2002-09)

[ftp://ftp.3gpp.org/Specs/archive/29\\_series/](ftp://ftp.3gpp.org/Specs/archive/29_series/)

10 (Non-patent reference 6) "General Packet Radio Service (GPRS); Service description; Stage 2 (Release 5)" 3GPP TS 23.060 V5.2.0. (2002-06)

[ftp://ftp.3gpp.org/Specs/archive/23\\_series/](ftp://ftp.3gpp.org/Specs/archive/23_series/)

(Non-patent reference 7) "IP Multimedia Subsystem (IMS); 15 Stage 2 (Release 5)" 3GPP TS 23.228 V5.6.0 (2002-09)

[ftp://ftp.3gpp.org/Specs/archive/23\\_series/](ftp://ftp.3gpp.org/Specs/archive/23_series/)

(Non-patent reference 8) "Diameter Base Protocol"

<http://www.ietf.org/internet-drafts/draft-ietf-aaa-diameter-15.txt>

20 (Non-patent reference 9) "PPP Extensible Authentication Protocol (EAP)"

<http://www.ietf.org/rfc/rfc2284.txt>

(Non-patent reference 10) 3GPP project

<http://www.3gpp.org>

25 (Non-patent reference 11) 3GPP2 project

<http://www.3gpp2.org>  
(Non-patent reference 12) "The Network Access Identifier"  
<http://www.ietf.org/rfc/rfc2486.txt>  
(Non-patent reference 13) "Numbering, addressing and  
5 identification (Release 5)" 3GPP TS 23.003 V5.3.0 (2002-  
06)  
[ftp://ftp.3gpp.org/Sepcs/archive/23\\_series/](ftp://ftp.3gpp.org/Sepcs/archive/23_series/)  
(Non-patent reference 14) "Port-Based Network Access  
Control" IEEE Std 802.1X-2001  
10 <http://standards.ieee.org/getieee802/>  
(Non-patent reference 15) "Diameter Extensible  
Authentication Protocol (EAP) Application"  
<http://www.ietf.org/internet-drafts/draft-ietf-aaa-eap-00.txt>  
15 (Non-patent reference 16) "Diameter NASREQ Application"  
<http://www.ietf.org/internet-drafts/draft-ietf-aaa-diameter-nasreq-09.txt>  
(Non-patent reference 17) "IPv6 Stateless Address  
Autoconfiguration"  
20 <http://www.ietf.org/rfc/rfc2462.txt>  
Usually WLAN and the inter-worked network are in  
different administrative domains, which means their  
address spaces are managed separately. Therefore, when a  
mobile terminal roams into a WLAN in a different domain  
25 than its home network, some address configuration must be

carried out to guarantee the continuous service delivery to the terminal. This address configuration could include for example IP address allocation, address registration, tunnelling set-up, etc.

5 For certain services delivered to the terminal over the WLAN, address restrictions would apply. For example, to access the IMS (non-patent reference 7) service in the 3G networks from the WLAN would require the terminal to own an address belonging to the network providing the IMS.

10 Consequently, a mobile terminal with parallel access to different services would be required to have multiple IP address configured.

In WLAN, terminals are not allowed to use any resources, e.g. send or receive normal data packets, 15 before they are authenticated, and authorized to do so. Using normal schemes, e.g. the one suggested in MIPv6, the address configuration could only happen after the successful authorization procedures. This kind of approach is slow, and is not able to meet requirements of 20 some of the services. In order to have the address configured before the authorization, relevant information needs to be integrated into the access control messages. The address management is usually based on the user's subscription information. Therefore, it must be 25 controlled by the mobile terminal's home network. For

certain external services, the address needs to be allocated from domain other than the home network. In this case, a mechanism is required to allow the home network to negotiate the address allocation, and other 5 information with that domain.

When a terminal changes its address, the end-to-end QoS associated to it would be affected. For example, a traffic filter based on source or destination address information would not be able to correctly classify the 10 streams if the address changed. For a WLAN that implements firewall or other traffic control functions, the terminal's new address also needs to be signalled, otherwise traffic could be blocked or dropped.

## 15 DISCLOSURE OF THE INVENTION

When a terminal enters a WLAN, it must go through the authentication, authorization procedures to gain access to the resources. In this invention, a solution is presented for address management that is integrated into 20 the access control mechanisms. By this integration, the terminal's address could be configured together with the granting of access. The terminal would reuse and extend the access control mechanisms, and therefore does not need to implement any new protocol. The configuration process 25 would be shielded by the inherent encryption and

protection of the access control process, and thus need no extra security setup.

The present invention also provides means for the terminal's home network to negotiate the address 5 management with the network that provides the service to the terminal. This kind of negotiation is a back-end process, and is transparent to the mobile terminal and WLAN. Result of the negotiation would be carried along to the WLAN and mobile terminal using the service 10 authorization procedures.

When parallel access sessions are present to the same terminal, multiple addresses could be required. The invention provides a method for the terminal to obtain address that binds to the session, using a fine grain 15 service authorization procedure. Each session would use the address attached to it, and transition to a new address is allowed.

The address management is also integrated with the policy control mechanisms. The policy control would 20 provide means for the terminal and its home network to configure the WLAN when necessary after an address alternation. QoS, or tunnelling information would be modified and provisioned according to the new status using channels available in the existing policy control 25 procedures. By this, a smooth address transition in the

roaming time could be achieved, and QoS interruption could be minimized.

#### BRIEF DESCRIPTION OF THE DRAWINGS

5 Fig. 1 is a block diagram showing an example of the network architecture that is used for managing the address allocation for the mobile terminal, tunnelling setup and service negotiation in the WLAN inter-working in the present invention;

10 Fig. 2 is a sequence diagram showing an example of the message sequence for the address allocation for the Mobile Terminal, tunnelling setup and service negotiation in the network architecture shown in Fig. 1;

15 Fig. 3 is a data structure diagram showing an example of the message structure used by the Mobile Terminal in the message exchanges shown in Fig. 2;

Fig. 4 is a data structure diagram showing an example of the message format of address allocation request used by the Mobile Terminal;

20 Fig. 5 is a state transition diagram showing an example implementation of the Home Network Authorizer in the framework shown in Fig. 1 for the Mobile Terminal address allocation, tunnelling setup and service negotiation in the WLAN inter-working in the present  
25 invention;

Fig. 6 is a flow chart showing an example of the flow chart that could be used for implementation of the request message processing procedure at the Home Network Authorizer;

5 Fig. 7 is a data structure diagram showing an example of the message structure used by Home Network Authorizer for negotiating Mobile Terminal service specification, address allocation and tunnel settings with Service Provider Network Server;

10 Fig. 8 is a data structure diagram showing an example of the message structure used by Home Network Authorizer for negotiating Mobile Terminal service specification, address allocation and tunnel settings with WLAN Server; and

15 Fig. 9 is a data structure diagram showing an example of the message structure used by Home Network Authorizer for updating the Mobile Terminal's status in the policy server of the Home Network domain.

20 BEST MODE FOR CARRYING OUT THE INVENTION

The present invention is to be used for the WLAN to inter-work with other networks. The inter-worked network could be another WLAN or a public cellular network. It is easy to deploy the invention in both of the cases. The 25 invention is to be used for the purpose of address

management and service provisioning relevant to the address transition (i.e. mobility control).

The deployment of the proposed scheme, no extra interface and protocol implementation are necessary. The 5 scheme would reuse the existing access control mechanisms, and extend some of the attributions to support the necessary functionalities. The address allocation and modification would be integrated with the service authorization procedures. Since the authorization 10 procedure is encrypted and protected by the credentials obtained from the authentication, the address information is also protected with same level of security. It would be shown as part of the authorization information, and could be transferred the same way as normal authorization 15 information. For example, it could be included in the Diameter (non-patent reference 8) as an authorization specific AVP, or an EAP (non-patent reference 9) attribute if an EAP method for authorization is available.

When a terminal enters the WLAN, it would be 20 authenticated and authorized before allowed to use the service. In the authorization procedure, the terminal would request for the service it tends to access. This information would be passed back to the terminal's home network by the WLAN. The terminal's home network decides 25 whether to allow the service based on the user's

subscription profile. Depending on the service requested, the terminal's home network also decides the address to be used for the service. For example, for an IMS service, the address needs to be allocated from the IMS address space, whilst for a local WLAN service, the address obtained locally would be sufficient. Also, tunnelling information related to the address management would be identified.

The address information would be included in the authorization information, and sent along with the authorization success message. Part of the information is destined for the WLAN, and part for the terminal, similar to the normal authorization procedure. For example, the address needs to be sent to the terminal so that it can configure itself, and the tunnelling information would be used by the WLAN if network tunnelling were necessary.

When any change in address is necessary, the re-authorization procedure could be used for a quick update without going through the service authorization details.

Policy control would be triggered when the terminal starts to access the service. Address information would be made available to the policy server at the terminal's home network. The policy server could then make policy decisions based on the address information. When address changes, the policy server would be notified to update the

corresponding policies, so that the QoS and service provisioning could be guaranteed.

To help understanding the invention, the following definitions are used.

5 A "WLAN" refers to wireless local area network. It contains arbitrary number of devices in order to provide LAN services to mobile terminals through wireless technologies.

10 A "3G network" refers to a 3<sup>rd</sup> generation public access network. An example could be the system defined by 3GPP (non-patent reference 10), or 3GPP2 (non-patent reference 11).

15 A "Mobile Terminal" refers to a device used for accessing the service provided by the WLAN and other networks through wireless technologies.

20 A "Home Network" refers to the network where the Mobile Terminal (MT)'s service subscription information stored. In the inter-working scenarios, it could be the network the MT originally subscribed to, or a visited network that is authorized to have full access to the MT's subscription information.

25 A "Service Provider Network" refers to the network where the service the MT requested is provided. It could be any network, e.g. the home network, the WLAN, or an external network.

A "Network Element" refers to any functioning device in the network that can carry out information processing.

A "Policy Server" refers to a network element that performs the policy control function of the network domain.

5 The policy control function includes, for example, the local resource allocation, packet filter updating, routing updating, etc.

An "Air Interface" refers to any radio access technologies for the mobile terminal to access the WLAN.

10 A "stream" is a gathering of packets transferred in the network that have certain attributes in common.

A "Traffic" is a gathering of streams transferred in the network.

15 A "flow" refers to the data path and the network resources needed for the data path used in delivering the stream.

"QoS" refers to the term Quality of Service of a data streams or traffic.

20 "Message" refers to the information exchanged between the Network Elements for the purpose of Inter-working control.

"Operation Sequence" refers to a series of Message Exchange between certain Network Elements in certain order for Inter-working control.

25 "Upper Layer" refers to any entity on top of the

current entity that processes the packet passed to it from the current entity.

“Client Based Tunnel” refers to the tunnelling scheme that one of the end points of the tunnel is the 5 Mobile Terminal.

“Network Based Tunnel” refers to the tunnelling scheme that the end points of the tunnel reside on Network Elements other than the Mobile Terminal.

In the following description, for purposes of 10 explanation, specific numbers, times, structures, protocol names, and other parameters are set forth in order to provide a thorough understanding of the present invention. However, it will be apparent to anyone skilled in the art that the presented invention may be practiced without 15 these specific details. In other instances, well-known components and modules are shown in block diagram in order not to obscure the present invention unnecessary.

Due to the highly mobile characteristics of the terminal, mobility control is one of the most prominent 20 issues for WLAN inter-working. When a terminal moves, it could be forced to use an address that is not local to its point of attachment. For example, for a 3G terminal roamed into the WLAN, it needs a 3G-domain address to access its home network’s service, e.g. IMS service. When 25 the terminal initiates the service inside the 3G networks,

the address is allocated according to 3G schemes, e.g. GPRS service (non-patent reference 6). This address would be bound to the terminal's 3G cellular interface. When a terminal enters the WLAN domain, it could desire to 5 communicate using its WLAN interface since that can provide higher throughput. For example, a PDA with dual interface, GPRS and IEEE802.11, would desire to use its GPRS interface on the road, and use its IEEE802.11 interface in the hotspot. When using the WLAN interface 10 accessing the 3G service, the terminal needs to continue using the same address obtained from the 3G interface. Otherwise, the terminal would face service interruption, and be forced to re-initiate the session, which is not desirable to the user. Since the address in use is not 15 local to the WLAN, a tunnel must be set up from the terminal to the Service Provider Network.

An example implementation of the invention for address allocation and tunnel set-up is shown in Fig. 1. To avoid confusion, only Network Entities that participate 20 in the signaling are shown.

The Mobile Terminal (101) is the entity that requests a certain service from the network. In real world, it could comprise several entities, e.g. a handset connected to the laptop computer via a Bluetooth link. It 25 is drawn as one set in Fig. 1 for the reason of simplicity.

Among the WLAN Functions (1001), the Access Point (105) is the entity that provides WLAN access to the Mobile Terminal (101). Access Point (105) would block all the data traffic from the Mobile Terminal (101) until it is 5 authorized to use the WLAN services. A control channel that only allows certain specific data packets is left open for the access control signaling. Mobile Terminal (101) communicates with the Access Point (105) over the wireless link (1011). This link could use any kind of 10 wireless technology, e.g. IEEE802.11, HiperLAN/2, Infrared, etc. This does not preclude the use of other technologies, e.g. Optical Fiber, for this link, if similar access control technology could apply. Another entity in the WLAN is the WLAN Management Server (WLAN Server) (102). 15 This WLAN Server (102) is in charge of the address space management, and resource management of the WLAN. It could reside on the WLAN gateway, or, in a simple WLAN, even collocate with the Access Point (105). The WLAN Server (102) communicates with Access Point (105) over interface 20 (1015). This is for WLAN resource control and service provisioning, e.g. QoS management over air interface. To manage the WLAN, the server could interact with other entities of the WLAN, e.g. the WLAN gateway or Firewall, which is not shown in the diagram.

25 In the terminal's Home Network (1002), a Home

Network Authorizer (103) controls the service authorization and address allocation. The Access Point (105) and WLAN Server (102) both communicate with the Home Network Authorizer (103) for service control information 5 via links (1012) and (1014). Physically, these links could be identical, i.e. between same end points, using the same protocol, and encapsulated in the same packet, but they are logically separated.

The Mobile Terminal (101) could request for any 10 service it subscribed to. These services could be in the Home Network (1002), a separate Service Provider Network (1003), or even the WLAN itself. When the service is provided by the Home Network (1002) or the WLAN, the Service Provider Network (1003) would overlap with these 15 networks, and thus the control functions could bind together. The Service Provider Network Management Server (Service Provider Network Server) (104) controls the service authorization, and address allocation in the Service Provider Network (1003). The Home Network 20 Authorizer (103) communicates with Service Provider Network Server (104) over a control interface (1013). In real implementation, the Service Provider Network (1003) could be the WLAN, the Home Network (1002) or another network. In case the service is provided in the Home 25 Network (1002), this interface becomes an internal

interface, and does not need to follow the exact format and using the same protocol as described in the following example implementation.

Fig. 2 shows an example operation sequence for the 5 address management for the WLAN inter-working using the above-described framework. In the operation, it is assumed that the Mobile Terminal (MT) (101) has already finished the WLAN association and authentication procedure (201). This means that the Mobile Terminal (101), and the 10 Access Point (105) has already mutually authenticated each other, and encryption protection has already been turned on for the following message exchanges. When the Mobile Terminal (101) wants to access any service over the WLAN, it sends out the MT\_Request\_A message (202A), over the 15 link (1011) to the Access Point (105) and destined to its Home Network Authorizer (103). This message is end-to-end protected by the keys generated from the authentication procedures (201). Fig. 3 shows an example implementation of the MT\_Request\_A message (202A).

20 The message starts with the Message\_Type field (301). This field identifies which kind of message is encapsulated, e.g. Request, Reply, etc. The length of this field is one octet. Message types are represented by integer numbers. This is to save the limited resources 25 for signaling over the air interface. It is obvious to

anyone skilled in the art that this field could adopt any other format when necessary. Following the Message\_Type field (301) is the Message\_Length field (302). It contains the information about the length of the whole 5 message, including the Message\_Type field (301). Next field is the Domain\_Name field (303). This field identifies the home domain of the Mobile Terminal (101). The Network Access Identifier (NAI) (no-patent reference 12) could be used, and it would be in the form of, for 10 example, "UserID@home.domain.3gpp.org". To protect the user identity, the UserID part before the "@" sign is using a wildcard value, e.g. "roamed". The home domain information is used for routing the message to the Mobile Terminal (101)'s Home Network Authorizer (103).

15 The above three fields, Message\_Type field (301), Message\_Length field (302) and Domain\_Name field (303), are protected by the security association between the Mobile Terminal (101) and the Access Point (105). This security association is obtained from the Authentication 20 procedure (201) for the protection of air interface. Therefore, the information contained in these fields could be accessed by the Access Point (105) for forwarding purpose. The fields following the Domain\_Name field (303) would be protected by the security association between the 25 Mobile Terminal (101) and Home Network Authorizer (103).

For example, it could be the public key of the Home Network Authorizer (103), or the session key derived from Authentication procedure (201). The UserID part from the Domain\_Name field (303) could be used to signal the index 5 of the keys that is used for the message protection.

After the Domain\_Name field (303) is the MT\_ID field (304). This field contains the information to uniquely identify the Mobile Terminal (101) in the Home Network (1002) context. This could be, for example, the IMSI 10 (non-patent reference 13) of the Mobile Terminal (101), or the TMSI (non-patent reference 13) gained in the authentication procedures. The Home Network Authorizer (103) uses this identifier to retrieve the user's 15 subscription information. It is obvious to anyone skilled in the art that any other format could be used in this field as long as the Home Network Authorizer (103) could map it to the actual user identity.

The next field is the Service\_Request field (305). This field is used by the Mobile Terminal (101) to 20 indicate the service it desires to access to the Home Network Authorizer (103). Since the message is between the Mobile Terminal (101) and its Home Network Authorizer (103), it is operator and network specific. For example, in a 3GPP network, this could be the APN (non-patent 25 reference 13) that identifies the GGSN to use and the

special service to access. It is obvious to anyone skilled in the art that other formats could be used if the Home Network (1002) is of another type. Other service request information could also be appended, e.g. the 5 bandwidth request. A possible value of the field could be "2M.bandwidth.request.IMS.foo.bar.operator-name.operator-group.gprs". The part after the "request" is the standard APN to identify the service, and the part before the "request" is the specific service request. The actual 10 request attribute is service dependent, and could be defined by the operator. The Mobile Terminal (101) could gains the knowledge of the format from the SIM or USIM card.

A Session\_ID field (306) provides the session 15 control information. This is used for the Mobile\_Terminal (101) to identify the session this service request concerned to the Home Network Authorizer (103). The identifier of the session should be locally unique within the Mobile\_Terminal (101). The Mobile\_Terminal (101) 20 should maintain a local record of all the service sessions. A new entry with a new session identifier would be created whenever a new service session starts. The entry would be removed when the session terminates, and the identifier would be freed for reuse. In the example implementation, 25 the field is 2 octets, and the identifier is in

hexadecimal value. It is obvious to anyone skilled in the art that other type of identifier supported by the terminal could be used. The MT\_ID field (304) and the Session\_ID field (306) uniquely identify a service session 5 at the Home Network Authorizer (103).

Address\_Request field (307) contains the information about the address allocation request from the Mobile Terminal (101). In the example implementation, a compound structure is used, as shown in Fig. 4. The first part of 10 the structure is the Address\_Type field (401). This would identify which type of address is supported by the Mobile Terminal (101). The size of this field is one octet. Possible value could be:

```
No_IP ::= 0x00;  
15 Single_Stack_IPv4 ::= 0x01;  
Single_Stack_IPv6_FullAddress ::= 0x02;  
Single_Stack_IPv6_Prefix ::=0x03;  
Dual_Stack_IPv4_PREFERRED ::= 0x04;  
Dual_Stack_IPv6_PREFERRED_FullAddress ::= 0x05;  
20 Dual_Stack_IPv6_PREFERRED_Prefix ::=0x06
```

It is obvious to any one skilled in the art that there could be more types supported, and other numbers used. The second part of the structure is the Suggestion\_Length field (402). This field indicates the 25 length of the following field, Address\_Suggestions field

(403). The Address\_Suggestions field (403) lists out the address that the Mobile Terminal (101) desires to be assigned. For example, an ongoing session is using a certain address, it would be important to have the same 5 address assigned to keep the session uninterrupted. The Address\_Suggestions field (403) could be a list of addresses. Each entry in the list starts with a one-octet type field stating the address type, e.g. IPv4, or IPv6, and followed by the actual address. For Home Network 10 Authorizer (103) that does not support the terminal address suggestion feature, the Suggestion\_Length field (402) and Address\_Suggestions field (403) would be silently ignored.

After the Address\_Request field (307) is the 15 Tunnel\_Request field (308). This field is used by the Mobile Terminal (101) to indicate which type of tunnel it supports. The first octet of the field indicates the length of this field, including itself. The content of this field could be a list, with each entry occupying two 20 octets. The first octet of each entry contains the identifier of the tunnel type the Mobile Terminal (101) supports. The value of the octet could be:

Network Tunnel -- Generic::= 0x01;

Network Tunnel -- Mobile IPv4::=0x02;

25 Client Tunnel -- Generic::= 0x04

Client Tunnel -- Mobile IPv4 ::= 0x05;  
Client Tunnel -- Mobile IPv6 ::= 0x06;  
No Tunnel ::= 0x08

It is obvious to anyone skilled in the art that  
5 other tunnel types could be defined and used in the field.  
The second octet of each entry indicates the direction of  
the tunnel. Possible value of this octet could be:  
Tunnel -- From terminal ::=0x01;  
Tunnel -- To terminal ::=0x02;  
10 Tunnel -- Bi-directional ::=0x03;  
The first entry in the list indicates the Mobile  
Terminal (101)'s preferred type.  
The next field in the MT\_Request\_A message (202A) is  
the WLAN\_ID field (309). It contains the information to  
15 identify the WLAN to the Home Network Authorizer (103), so  
that it could make decisions based on the location, or  
provide location-based service to the Mobile Terminal  
(101). The WLAN\_ID could be obtained from the  
authentication procedures, or from the broadcasted  
20 information from the Access Point (105), e.g. the SSID in  
IEEE802.11 network. A Mobile Terminal (101) local  
identifier is also included. This is for the Access Point  
(105) to identify the terminal.

25 The last field is the Security\_Field (310). This  
field contains the information to protect the message.

The exact algorithm used for the field is negotiated between the Mobile Terminal (101) and its Home Network Authorizer (103). This could be settled at the user subscribing time, or saved into the SIM or USIM card of 5 the terminal. It could also be implemented as software module, and to be downloaded whenever necessary.

The fields in the MT\_Request\_A message (202A) may not need to follow the exact sequence as described above. For example, in real implementation, the fields (304) to 10 (309) could be placed in any order as long as they place a field identifier in the front.

In real implementation, the message could be carried over the link (1011) using any suitable mechanism. For example, in an IEEE802.11 network, it could be implemented 15 as an EAP message, and use the EAPOL defined in IEEE802.1x to carry (non-patent reference 14).

When the Access Point (105) received this message, it would retrieve the home domain information from the Domain\_Name field (303). The Access Point (105) could 20 obtain the Home Network Authorizer (103)'s address using the domain information, e.g. make a DNS enquiry. The Access Point (105) would forward the message to the corresponding Home Network Authorizer (103) according to this information. In a certain case, the WLAN would have 25 a central AAA server, the Access Point (105) would forward

the message to the AAA server directly, and the WLAN AAA server would parse the domain information, and forward the message to the actual Home Network Authorizer (103). It is assumed that between the Access Point (105) and the 5 Home Network Authorizer (103), a secure link exists. This could be setup during the authentication procedure (201), or dynamically setup using the security association derived from that process.

The Access Point (105) need not participate in the 10 message processing, and therefore need not to implement the whole stack to parse the message. It would only need to read the message type, and do the re-encapsulation and forwarding, shown as the step of MT\_Request\_B message (202B). The protocol used for the forwarding could be any 15 suitable AAA protocol (e.g. the EAP application for Diameter (non-patent reference 15) or NASREQ application for Diameter (non-patent reference 16)). Those protocols are already available on the Access Point (105) for the purpose of authentication. Therefore, the MT\_Request\_A 20 message (202A) is essentially sent end-to-end from Mobile Terminal (101) to the Home Network Authorizer (103), similar to the end-to-end authentication procedure (201).

Fig. 5 shows an example implementation of the Home 25 Network Authorizer (103)'s state machine. The Home Network Authorizer (103) starts from the Init state (501)

to the Idle state (502), performing the process `Initiate()` in the transition (5001). The `Initiate()` process includes any necessary steps to establish connections with other backend servers, security associations, etc. It is 5 obvious to anyone skilled in the art that other process could be involved depending on the setting in the real implementation.

When the Home Network Authorizer (103) received the `MT_Request_B` message (202B) forwarded from the Access 10 Point (105) in the transition (5002), it would transit to the state `Message Decrypt` (503). Fig. 6 shows an example of the implementation of `Message Decrypt` (503) state. In the `Message Decrypt` (503) state, the Home Network Authorizer (103) would decrypt the fields in the 15 `MT_Request_B` message (202B) using the keys identified by the `Domain_Name` field (303) field in step (6001). If the message is damaged, or detected modified using the `Security_Field` (310), in step (6002), the Home Network Authorizer (103) would set the flag to `Bad Message` in step 20 (6013), and the state machine would transit to `Service Reject` state (504) in the transition (5004).

From the `MT_Request_B` message (202B), Home Network Authorizer (103) is able to gain the information about the identity of the terminal from the `MT_ID` field (304) in 25 step (6003). Using the identity, Home Network Authorizer

(103) would retrieve the user's subscription information from its database or a backend server (e.g. HSS in 3GPP network). The Home Network Authorizer (103) would also parse the service request information obtained from the 5 Service\_Request field (305) in step (6004). The service request could include various service specific information embedded, e.g. the bandwidth, delay, jitter, etc.

Decision would be made in the Home Network Authorizer (103) using the user subscription information on whether 10 to deny the service to the user in step (6005). If the service requested is not supposed to be granted based on the user's subscription, the Home Network Authorizer (103) would set the flag to Deny of Service in step (6013), and the state machine would transit to Service Reject state 15 (504) in the transition (5004). If the service is permitted, the Home Network Authorizer (103) would search its records for the terminal of the service for the session identifier, received in the Session\_ID field (306) in step (6007). If a record exists with the same session 20 identifier, it means this is a handover request, and the terminal should be allocated the same address, so that the service session would not be interrupted. If no record exists, it means it is a new request, and a record entry should be generated in step (6008), and stored in the Home 25 Network Authorizer (103)'s storage, or update the backend

database, e.g. the HSS. The Home Network Authorizer (103) would also identify the Service Provider Network (1003) using the service information, and a connection would be setup with the Service Provider Network Server (104).

5       From the Address\_Request field (307), the Home Network Authorizer (103) obtains the address the Mobile Terminal (101) desires to use in step (6009). If the Home Network Authorizer (103) does not wish to support this function due to operator policy or anything else, it can 10 silently ignore this information. The Mobile Terminal (101) should always use the final address allocated from the Home Network Authorizer (103). The Home Network Authorizer (103) would decide from the service requested whether the address should be allocated locally or in the 15 Home Network (1002), or in the Service Provider Network (1003). For example, if a user is only allowed to use the WLAN local service, the address should be allocated inside the WLAN, while for a user subscribed to a VPN service, it should be allocated with an address in that VPN.

20       The Home Network Authorizer (103) retrieves the tunnel type supported by the Mobile Terminal (101), from the Tunnel\_Request field (308) in step (6010). This information would be used to set up the tunnels for the service provisioning. The Mobile Terminal (101) could 25 list out more than one tunnel type, and the first one in

the list is the preferred type. The Home Network Authorizer (103) needs to check with the Service Provider Network Server (104), and decide which type to use. Extra information, for example the direction of the tunnel, 5 could also be included.

From the WLAN\_ID field (309), the Home Network Authorizer (103) would get the identity of the Wireless LAN that the Mobile Terminal (101) is currently associated with in step (6011). Using this information, the Home 10 Network Authorizer (103) would locate the corresponding WLAN Management Server (102). This could be stored in the Home Network Authorizer (103)'s database as part of the roaming agreement, or be retrievable from the backend server (e.g. HSS). A secure link would be established 15 after the server information is obtained. This link is used for the following service message signaling.

After obtained all the information, the Home Network Authorizer (103) would form the Service\_Request message (203) and the WLAN\_Request message (205). This message 20 would be sent out when the state machine of the Home Network Authorizer (103) transits to the Wait State (504).

Fig. 7 shows an example of the implementation of the Service\_Request message (203). The message starts with the Home\_Network\_ID field (701). This field contains the 25 information about the Mobile Terminal (101)'s home network

identifier. It could be an operator's name, or a subsystem of a big network. The identifier should be globally unique. DNS name of the network, e.g. "network.operator.3gpp.org", is a good candidate for this 5 identifier. The presence of the home network information enables the Service Provider Network Server (104) to apply network policies, e.g. roaming agreements, to the service request. The user profiles are managed by the Home Network (1002), and therefore the user information should 10 not be sent to the Service Provider Network Server (104). However, to enable finer control of the service, user priority/grouping information could be attached to the message. This could be concatenated with the home network identifier, e.g. "goldmember.network.operator.3gpp.org". 15 The Service Provider Network Server (104) could use this to differentiate the user when granting services.

The next field is the MT\_ID field (702). This field contains the information about the Mobile Terminal (101)'s identifier. It is used by the Home Network Authorizer 20 (103) for service tracking. The identifier could be the terminal's IMSI, or a temporary ID allocated by the Home Network Authorizer (103) specific for the service session. It should be consistent for the whole lifetime of the service session.

25 A Session\_ID field (703) follows the above field.

It is the session identifier allocated by the terminal. The Service Provider Network Server (104) should keep a record of all the on-going session information. Therefore, when the session identifier exists in the database, it 5 means the service request is triggered by a handover, and therefore should use the same configurations to avoid service interruption. For example, when a session is active, the Service Provider Network Server (104) should allocate the same address for the Mobile Terminal (101), 10 so that the communication with the correspondence node can continue without any signaling.

The Address\_Request field (704) is similar to that in the MT\_Request\_A message (202A). This part indicates to the Service Provider Network Server (104) the type of 15 address to allocate, e.g. IPv6. Similar to the Address\_Request field (307) of the MT\_Request\_A message (202A), it also provides address requested by the Mobile Terminal (101). If the Service Provider Network Server (104) does not want to support this function, it could 20 ignore this information. If the Home Network Authorizer (103) decides the address needs not to be allocated from the Service Provider Network (1003), this field would be omitted.

The Service\_Spec field (705) is a compound field. 25 It contains the information of the specific requirements

from the Home Network Authorizer (103) based on the user's subscription. A possible implementation (Data Structure 1) of this field is shown below.

```
struct Service_Spec {  
    5      u_long bitrate_avg;  
          u_long bitrate_max;  
          int deliver_order;  
          int MTU_size;  
          double delay;  
    10     double jitter;  
          int priority;  
          int service_direction;  
          int QoS_type  
          struct timeval start_time;  
    15     struct timeval end_time;  
};
```

Among the attributes, `bitrate_avg` and `bitrate_max` represent the guaranteed and maximum bit-rate for the service requested. The `deliver_order` attribute indicates whether the deliver is required to be in order. The `MTU_size` specifies the maximum data unit size to be transferred for the service. The `delay` and `jitter` fields specify some basic QoS attributes for the service. The `priority` attribute indicates the handling priority of the data traffic for this service. The `service_direction`

attribute indicates whether the service is uni-directional or bi-directional. The QoS\_type attribute specifies the QoS schemes to be used for provisioning the service, e.g. DiffServ, or InterServ with RSVP, etc. The start\_time and 5 end\_time specify the starting and ending time of the service. The Service Provider Network Server (104) could use this information to schedule the resources for the service. It is obvious to anyone skilled in the art that other service specific attributes could be included in the 10 structure in real implementation.

After the Service\_Spec field (705) is the Tunnel\_Spec field (706). This field contains the tunnel information, and is similar to the Tunnel\_Request field (308) of the MT\_Request\_A message (202A), but with some 15 extra information attached. For example, for the network tunnel entry, the WLAN end point is provided, and for the terminal tunnel, a security key could be attached for data encryption.

The last field of the Service\_Request message (203) 20 is the Security\_Field (707). This field is used to protect the whole message using the security association between the Home Network Authorizer (103) and Service Provider Network Server (104). The exact algorithm used for this is implementation dependent.

25 It is obvious to anyone skilled in the art that the

fields in the Service\_Request message (203) need not to be the described order. In real implementation, the Home Network Authorizer (103) and Service Provider Network Server (104) could negotiate any suitable order for the 5 optimization of signaling.

After the Service Provider Network Server (104) received the Service\_Request message (203), it would carry out the Service Address Management procedure (204). In this procedure, the Service Provider Network Server (104) 10 would search its database for the session identifier contained in the Session\_ID (703). If the session identifier for the same Mobile Terminal (101), exists Service Provider Network Server (104) copies all the information in its record, e.g. address of the MT, 15 specification of the service, etc, and send that back to the Home Network Authorizer (103) as the reply message directly.

If the session identifier does not exist, the Service Provider Network Server (104) would create a new 20 entry using the new session identifier as index in its database. The Service Provider Network Server (104) would check the Address\_Request field (704), and allocate a suitable address for the Mobile Terminal (101) based on the address type specified in this field.

25 The Service Provider Network Server (104) checks the

Service\_Spec field (705) from the Home Network Authorizer (103). If the requested service is not supported, a message which indicates failure would be sent back to the Home Network Authorizer (103). Some error code could be 5 used to specify the cause of the failure. If certain attributes in the Service\_Spec field (705) exceed the current capability of the Service Provider Network (1003), the Service Provider Network Server (104) would try to negotiate with the Home Network Authorizer (103) for a new 10 set of attributes. This could be achieved by having the same Service\_Request message (203) sent back to the Home Network Authorizer (103) with the Service\_Spec field (705) modified to proposed value by the Service Provider Network Server (104).

15 The Service Provider Network Server (104) checks the Tunnel\_Sepc field (706) for the matched tunnel type. There could be multiple matches, but the Service Provider Network Server (104) should choose the first match. For a Network Based Tunnel type, the Service Provider Network 20 Server (104) needs to prepare the tunnel end points information in the reply message. For the Client Based Tunnel, the Service Provider Network Server (104) would prepare tunnel type specific information, and include that in the reply information. For example, for a Mobile IPv6 25 type of scheme, the Service Provider Network Server (104)

needs to assign a Home Agent for the Mobile Terminal (101), and include possible some security information in the reply message too. Directional information, e.g. uni-direction, bi-direction, would also be attached to the 5 tunnel information fields.

The Service Provider Network Server (104) replies to the Home Network Authorizer (103) with the Service\_Reply message (205). The Service\_Reply message (205) could use the same structure as the Service\_Request message (203) as 10 shown in Fig. 7. The contents of the Home\_Network\_ID (701), MT\_ID (702) and Session\_ID (703) fields are copied directly from the corresponding Service\_Request message (203). These fields would be used by the Home Network 15 Authorizer (103) to match the request and reply message pair when the signaling link is reused for multiple terminals.

The content of the Address\_Request field (704) field in the Service\_Reply message (205) contains the address(es) allocated to the Mobile Terminal (101). It 20 could be a list of address entries with the first octet indicating the length of the field in byte. The following part of the field is the address list, with one octet indicating the address types followed by the actual address. Wildcard address is allowed. For example, if 25 the address field is filled with all zero, it is

indicating the Mobile Terminal (101) forms an address using WLAN local mechanisms (e.g. IPv6 auto-configuration) (non-patent reference 17) or DHCP.

The content of the Service\_Spec field (705) in the 5 Service\_Reply message (205) contains the attributes agreed by the Service Provider Network Server (104). It is identical to the Service\_Spec field (705) in the corresponding Service\_Request message (203), if all the attributes are approved by the Service Provider Network 10 Server (104). Otherwise, it is the counter proposal of the Service Provider Network Server (104) to the Home Network Authorizer (103).

The Tunnel\_Spec field (706) in the Service\_Reply message (205) contains the tunnel setting chosen by the 15 Service Provider Network Server (104). The exact content of this field is tunnel type specific. If a Client Based Tunnel type were chosen, only one setting is necessary. For example, if the Mobile IPv6 were agreed, the field would contain the address of the Home Agent assigned to 20 the Mobile Terminal (101), and a security key for Binding Update authentication, etc. The address in the Address\_Request field (704) would be used as the home address of the Mobile Terminal (101). If Network Based Tunnel type is chosen, the field would contain, for 25 example, the end-point address, tunnel identifier, etc,

and all the necessary details for each supported tunnel type.

In parallel with the Service\_Request message (203), the Home Network Authorizer (103) would send a 5 WLAN\_Request message (206) to the WLAN Server (102). This message negotiates the necessary setting for provisioning service in the WLAN. An example of the implementation of this message is shown in Fig. 8.

The WLAN\_Request message (206) contains two similar 10 fields, Home\_Network\_ID field (801) and MT\_ID field (802), as the Service\_Request message (203). The Home\_Network\_ID field (801) contains the identifier of the subscriber's home network. It is passed to the WLAN Server (102) in case some network policy would apply to the service 15 provisioning. The MT\_ID field (802) is used to track the location of the Mobile Terminal (101). It could be, for example, the Access Point identifier concatenated with the Mobile Terminal (101)'s lower layer identifier, e.g. MAC address.

20 The Address\_Alloc field (803) is a flag to indicate whether a WLAN local address needs to be allocated for the Mobile Terminal (101), and the address types to be used. The Home Network Authorizer (103) would decide whether the local address is necessary based on the tunnel scheme 25 chosen. In the example implementation, the first octet of

this field indicates whether allocation is necessary with the following definition:

```
No_Allocation ::= 0x00;  
Single_Stack_IPv4 ::= 0x01;  
5 Single_Stack_IPv6_FullAddress ::= 0x02;  
Single_Stack_IPv6_Prefix ::=0x03;  
Dual_Stack_IPv4_PREFERRED ::= 0x04;  
Dual_Stack_IPv6_PREFERRED_FullAddress ::= 0x05;  
Dual_Stack_IPv6_PREFERRED_Prefix ::=0x06  
10 It is obvious to anyone skilled in the art that  
other values could be used in the real implementation of  
this message.
```

The Service\_Support field (804) is a compound field that includes all the necessary attributes to support the 15 service provisioning in the WLAN. The actual content is service specific. An example content of this field is as that described in Data Structure 1.

The Tunnel\_Setup field (805) is also a compound field. It uses the similar format as the Tunnel\_Spec 20 field (706) in the Service\_Request message (203).

The last field of the WLAN\_Request message (206) is the Security\_Field (806). This field is using the security association to protect the integrity of the whole message. Algorithm used for the computation of this field 25 is implementation dependent.

The WLAN Server (102) would carry out the WLAN Service Address Management (207) after receiving the WLAN\_Request message (206). For example, if the local IPv6 address allocation were requested by the Home Network 5 Authorizer (103), the WLAN Server (102) would locate the suitable network section and allocate the IPv6 address for the terminal. If necessary, the WLAN Server (102) would also update the gateway, or firewall of the WLAN of the new address allocation, so that the Mobile Terminal (101) 10 is able to access the service using this allocated local address.

The WLAN Server (102) would also use the information in the Service\_Support field (804) to perform local admission control. Similar to the Service Provider 15 Network Server (104), if a certain attribute exceeds the WLAN's current capacity, the WLAN Server (102) would try to negotiate a new set of service specification with the Home Network Authorizer (103), e.g. reduce the bit rate, change the service time interval, etc.

20 If a Client Based Tunnel scheme is chosen by the Home Network Authorizer (103), the WLAN Server (102) does not need do any special setup. When the Network Based Tunnel scheme is used, the WLAN Server (102) needs to identify the tunnel end points using the information from 25 the MT\_ID field (802).

The WLAN Server (102) replies the WLAN\_Request message (206) with the WLAN\_Reply message (208). The WLAN\_Reply message (208) uses the similar structure as the WLAN\_Request message (206), as shown in Fig. 8. The 5 Home\_Network\_ID field (801) and MT\_ID field (802) are copied directly from the corresponding WLAN\_Request message (206). These fields are used by the Home Network Authorizer (103) to match the request and reply message pair.

10 The Address\_Alloc field (803) in the WLAN\_Reply message (208) contains the information of the WLAN local address allocated to the Mobile Terminal (101). The first octet of the field indicates the type of the address, as defined for Address\_Request field (307) in MT\_Request\_A 15 message (202A). The following part of the field contains the actual address allocated for the Mobile Terminal (101). For example, if an IPv6 address is allocated, the first octet would be 0x02, and the next 32 octets contain the actual IPv6 address.

20 The Service\_Support field (804) in the WLAN\_Reply message (208) contains the information of the service attributes as defined for the WLAN\_Request message (206). If these service attributes were acceptable by the WLAN, WLAN Server (102) would copy them directly from 25 WLAN\_Request message (206). If WLAN Server (102) could

not agree on the attributes, it would send a new proposal in the WLAN\_Reply message (208) with attributes set to new values.

The Tunnel\_Setup field (805) in the WLAN\_Reply message (208) is the tunnel information for the Mobile Terminal (101). It specifies the tunnel type to be used in the first octet, and the tunnel type specific data in the following octets. For example, if Mobile IPv6 is used for the data traffic, only tunnel type is present in this field, and address in the Address\_Alloc field (803) would be used as the care-of-address of the Mobile Terminal (101). If Mobile IPv4 is used, this field would contain the tunnel type in the first octet followed by the Foreign Agent address allocated to the Mobile Terminal (101).

The Home Network Authorizer (103) would consolidate the information from the WLAN Server (102) and the Service Provider Network Server (104) after receiving the Service\_Reply message (205) and WLAN\_Reply message (208). If the Service\_Spec field (705) or Service\_Support field (706) contains different attribute values than that in the Service\_Request message (203) or WLAN\_Request message (206), re-negotiation of service specification is necessary. The Home Network Authorizer (103) would check the new values proposed by the Service Provider Network Server (104) or the WLAN Server (102). If these new

values were acceptable, it would confirm the new setting using the `SPN_Config` message (210) and `WLAN_Config` message (211).

The message pairs `Service_Request` message (203),  
5 `Service_Reply` message (205) and `WLAN_Request` message (206),  
`WLAN_Reply` message (208) do not have time correlation.  
They could happen in parallel, or one after another  
depending on the implementation of the Home Network  
Authorizer (103). For example, the Home Network  
10 Authorizer (103) could decide to send out the `WLAN_Request`  
message (206) instead of `Service_Request` message (203) if  
the connection with the WLAN Server (102) is idle.

The `SPN_Config` message (210) is sent by the Home  
Network Authorizer (103) to the Service Provider Network  
15 Server (104) to confirm the new service parameters if a  
re-negotiation is needed. Same message format as the  
`Service_Request` message (203) is used for the `SPN_Config`  
message (210). Some fields (e.g. the `Address_Request`)  
would be omitted if not used.

20 Tunneling information could also be attached if  
necessary. For example, when Client Based Tunnel (e.g.  
Mobile IP) is used, the care-of-address of the Mobile  
Terminal (101) allocated by the WLAN Server (102) would be  
inserted to the `Tunnel_Request` field (308). If a Network  
25 Based Tunnel is used, the tunnel end-point address, port

number, etc, of the WLAN would be forwarded in this message.

The WLAN\_Config message (211) serves the similar purpose. The Home Network Authorizer (103) uses this 5 message to confirm new settings with the WLAN Server (102) if necessary. The message could also be used for forwarding tunnel information. For example, when the Network Based Tunnel is used, the tunnel end point address, port number, etc, of the Service Provider Network (1003) 10 would be forwarded to the WLAN Server (102) in this message. WLAN Server (102) would then instruct the corresponding nodes to set up the tunnel. When the Client Based Tunnel is used, the terminal address would be included in the message, so that the WLAN could open the 15 firewall for the data traffic.

It is obvious to anyone skilled in the art that these two messages, SPN\_Config message (210) and WLAN\_Config message (211) could be used by the Home Network Authorizer (103) to revoke the resources allocated 20 for the Mobile Terminal (101) when the service session is over. For example, when the Home Network Authorizer (103) detected that the Mobile Terminal (101) is no longer in the WLAN, it would issue a WLAN\_Config message (211) with Service\_Support field (804) set to all zero. After 25 receiving this kind of message, WLAN Server (102) would

free all the resources allocated to the Mobile Terminal (101), and perform other appropriate actions.

The Home Network Authorizer (103) would send an MT\_Reply\_B message (212B) as the reply to the MT\_Request\_B message (202B). This message would be forwarded by the Access Point (105) or any other attendant, to the Mobile Terminal (101) as the MT\_Reply\_A message (212A). The MT\_Reply\_A message (212A) and MT\_Reply\_B message (212B) have the identical contents and format. Network Elements 5 between the Home Network Authorizer (103) and Mobile Terminal (101) has no access to the contents of these messages, and the Access Point (105) would only re-encapsulate the whole message and forward it. The MT\_Reply\_A message (212A) or MT\_Reply\_B message (212B) is 10 encrypted with the security association shared between the Mobile Terminal (101) and Home Network Authorizer (103). Since the MT\_Reply\_A message (212A) is the reply to the corresponding MT\_Request\_A message (202A), the Access Point (105) would know which Mobile Terminal (101) to 15 forward.

20

If the WLAN Server (102) is on the path of the MT\_Reply\_B message (212B), the WLAN\_Config message (211) could be piggybacked to the same message. For example, if the WLAN Server (102) were the AAA server using Diameter 25 in the WLAN that would forwards the MT\_Reply\_B message

(212B) to the Mobile Terminal (101), the MT\_Reply\_B message (212B) could be encapsulated in the Diameter-EAP-Answer AVP, while WLAN\_Config message (211) being encapsulated in another AVP in the same message. It is 5 obvious to anyone skilled in the art that same kind of scheme could be used even other transportation protocol is utilized.

The MT\_Reply\_A message (212A) has the same structure as the MT\_Request\_A message (202A), as shown in Fig. 3. 10 The Message\_Type field (301) has the same format as that of the MT\_Request\_A message (202A). It would use an integer to indicate that this message is a Reply instead of Request. The Message\_Length field (302) indicates the total length of the message including the Message\_Type 15 field (301). The Domain\_Name field (303) and the MT\_ID field (304) in the MT\_Reply\_A message (212A) are the same as those in the MT\_Request\_A message (202A). It is obvious to anyone skilled in the art that these fields could be omitted in the real implementation for signaling 20 optimization.

The Service\_Request field (305) in the MT\_Reply\_A message (212A) is used to contain the service specific information set by the Home Network Authorizer (103) based on the user's subscription. For example, if a user 25 requested for the IMS service, this could be the P-CSCF

address. It is obvious to anyone skilled in the art that other information necessary to the service provisioning could be included in this field. The exact format of this field is service dependent.

5       The Session\_ID field (306) in the MT\_Reply\_A message (212A) is copied directly from the MT\_Request\_A message (202A). It could be omitted in the real implementation if not required by the Mobile Terminal (101).

10      The Address\_Request field (307) in the MT\_Reply\_A message (212A) contains the address allocated to the Mobile Terminal (101). It should be used by the service application as the source address. First octet of this field is the address type, and followed by the actual address. For example, if an IPv6 address prefix was 15 allocated, the first octet would be 0x03, and the following 32 octets contains the prefix information to be used by the Mobile Terminal (101) to form the actual IPv6 address. Other address information, e.g. WLAN gateway address or DNS server address, could also be included.

20      These attributes would follow the address information described above. Wildcard value of all zero indicates that the Mobile Terminal (101) should use local stateless mechanism to obtain the actual information.

25      The Tunnel\_Request field (308) in the MT\_Reply\_A message (212A) contains the tunneling setting for

accessing the service requested by the Mobile Terminal (101). It would be tunnel type dependent. The first octet of this field indicates the tunnel types used.

For example, if Client Based Tunnel type Mobile IPv6 5 were used, the value would be 0x06, as defined for the tunnel types in the MT\_Request\_A message (202A). Following the type attribute, there would be the care-of-address allocated by the WLAN, and the Home Agent address, and the security keys if necessary. The address in the 10 Address\_Request field (307) would be the Home Address allocated to the terminal.

If a Network Based Tunnel type were used, following the type attribute, there would be the address of the local end-point of the tunnel, and the security keys for 15 the Mobile Terminal (101) to securely communicate with the end-point.

The WLAN\_ID field (309) in the MT\_Reply\_A message (212A) is copied directly from the MT\_Request\_A message (202A). It could be omitted in real implementation for 20 optimization of the signaling.

The Security\_Field (310) of the MT\_Reply\_A message (212A) is used for protect the integrity of the whole message. It uses the security association between the Mobile Terminal (101) and Home Network Authorizer (103). 25 It should use the same algorithm as that for the

MT\_Request\_A message (202A).

After receiving the MT\_Reply\_A message (212A), the Mobile Terminal (101) would retrieve all the necessary information, and configure accordingly. The Mobile 5 Terminal (101) could start the actual service session (213) using the setting.

In real implementation, a Mobile Terminal (101) could request for a few service at the same time, e.g. a Voice-over-IP session together with a video streaming 10 session. This would involve different Service Provider Network in the signaling. Same mechanism and message structure described above could be used in the scenario by aggregating several service requests in the same message. For example, in the MT\_Request\_A message (202A), there 15 could be multiple sets of fields; Service\_Request field (305), Session\_ID field (306), Address\_Request field (307) and Tunnel\_Request field (308). These four fields would be grouped, and for each service requested by the Mobile Terminal (101), one group of these four fields would be 20 included. For example, a MT\_Request\_A message (202A) requesting for a voice-over-IP session and a video streaming session, two groups of the listed four fields would be present.

After receiving the MT\_Request\_B message (202B) that 25 contains the same contents as the MT\_Request\_A message

(202A), the Home Network Authorizer (103) retrieves information from each set of these four fields corresponding to one specific service requested by the Mobile Terminal (101). Home Network Authorizer (103) 5 would perform signaling for each of the requested services as described above for the single service request. For example, the Home Network Authorizer (103) would send Service\_Request message (203) to both the IMS sub-system and the network which provides the streaming service.

10 While for the WLAN\_Request messages (206) for different services, they are destined for the same WLAN. The Home Network Authorizer (103) could be aggregate the information, and send only one message. If multiple WLAN\_Request messages (206) need to be sent to the same 15 WLAN, only one of them needs to request for the local address allocation.

The Home Network Authorizer (103) would aggregate all the service information into one MT\_Reply\_B message (212B) according to the order of the service requested, 20 and forward that to the Mobile Terminal (101) through the Access Point (105). Mobile Terminal (101) could then configure itself using the information in the aggregated MT\_Reply\_A message (212A).

If the Mobile Terminal (101) requests multiple 25 services in parallel, it is possible that different

addresses are allocated to the terminal from different Service Provider Networks. It is also possible that different tunnels are setup for different service sessions. In this scenario, a special mid-layer processor is

5 required. The service session identifier, as used in the Session\_ID field (306) would be used by the mid-layer processor to multiplexing the address and tunnel setting.

The mid-layer processor in the Mobile Terminal (101) would maintain a local database of the address and tunnel

10 information for different service sessions. When a service session is generated at the Mobile Terminal (101), the mid-layer processor would create an identifier for it. This is the session identifier that would be used in the Session\_ID field (306) of the MT\_Request\_A message (202A).

15 After receiving the MT\_Reply\_A message (212A) that contains all the address and tunnel information, the mid-layer processor would create a new entry in its database which contains all the information indexed by the session identifier. When a service application needs to initiate

20 a new connection session, it sends the request with the session identifier to the mid-layer processor. The mid-layer processor would retrieve corresponding address and tunnel information from its database using the session identifier. The address and tunnel information would be

25 used by the normal stack, e.g. IP layer, to create

suitable binding, e.g. socket, for the connection.

It is obvious to anyone skilled in the art that in real implementation, there could be WLAN that has no controller, i.e. no WLAN Server (102). In this case, the 5 Mobile Terminal (101) has to use those WLAN local mechanisms for address allocation and tunnel setup. The Home Network Authorizer (103) would set the Address\_Request field (307) and Tunnel\_Request field (308) in the MT\_Reply\_A message (212A) to all zero, this would 10 force the Mobile Terminal (101) to use WLAN mechanism, e.g. DHCPv6, MIPv6, etc, to configure the address.

In a certain case, the Mobile Terminal (101) would desire to cancel the service registration in the WLAN. It is obvious to anyone skilled in the art that the above- 15 described mechanism could also be used to de-register the service. The Mobile Terminal (101) could send out a MT\_Request\_A message (202A) with Service\_Request field (305) set to a special value indicating the terminating of service. For example, the Service\_Request field (305) 20 could include a value as  
"terminate.request.IMS.foo.bar.operator-name.operator-group.gprs". The "terminate" before the "request" keyword is the flag to terminate the service indicated by the APN attached after the "request" keyword. The Session\_ID 25 (306) field of the MT\_Request\_A (202A) message would be

set to the session identifier of the service to be terminated. The Address\_Request (307) and Tunnel\_Request (308) fields could be omitted for this type of MT\_Request\_A message (202A).

5       The Home Network Authorizer (103) processes the MT\_Request\_A (202A) message as normal. When it found the "terminate" keyword in the Service\_Request (305) field, it would retrieve the service session identifier from the Session\_ID (306) field. The Home Network Authorizer (103) 10 would search its database for the session entry created at service registration time. This session entry would store the information about the settings of the service, e.g. the address allocated, the tunnel setting, etc. Using the information, the Home Network Authorizer (103) would send 15 Service\_Request (203) message to the Service Provider Network Server (104), and WLAN\_Request (206) message to the WLAN Server (102) as normal. In these messages, the Service\_Spec (705) field and Service\_Support (804) are set to all zero.

20       The Service Provider Network Server (104) and WLAN Server (102) would process the message as normal. When they read the all zero Service\_Spec (705) field or Service\_Support (804) field, they would know it is a service termination request. These two servers would 25 search their database for the service session entry

created at the service registration time, and free corresponding resources, e.g. the IP address, reserved bandwidth, etc, for the service session.

A MT\_Reply\_A message (212A) would be sent back to 5 the Mobile Terminal (101) after the Home Network Authorizer (103) received notification from Service Provider Network (1003) and the WLAN. This message is to notify the success terminating of the service, and free of the reserved resources. In this MT\_Reply\_A (212A) message, 10 the Service\_Request (305) contains the information about the result. For example, following value could be used in this field, "removed.request.IMS.foo.bar.operator-name.operator-group.gprs", where the "removed" keyword before the "request" keyword indicates the success 15 deregistration of the service. It is obvious to anyone skilled in the art that extra information could be included, e.g. appended after the "removed" keyword.

In the process of provisioning service to the Mobile Terminal (101), policy control would involve. For example, 20 a terminal using its GPRS interface is allowed 149Kbps access rate. When this terminal roams into a WLAN, it transits to use its WLAN interface for accessing the same service. Since the WLAN provides much higher air interface bandwidth, the terminal is expected to enjoy 25 higher access rate (e.g. 1 Mbps). In order to achieve

this higher service rate to the Mobile Terminal (101), policy control framework needs to be invoked to modify corresponding policy settings, e.g. gateway filters. In the above example, the control point, e.g. the GGSN would 5 only reserve 149Kbps bandwidth for the terminal's service when it initiates the service using the GPRS interface. When the Mobile Terminal (101) registers the service session again using the WLAN service, the policy server should modify the settings at the GGSN to the 1Mbps. It 10 is obvious to anyone skilled in that art that other kinds of setting and a control node would be involved in the policy control.

This kind of policy control should be based on the user's subscription, and therefore in the Home Network 15 domain. The present invention uses the Home Network Authorizer (103) to handle the service request and address (tunnel setup). Therefore, it has all the necessary information for the policy control decision. This information could be passed by the Home Network Authorizer 20 (103) to the Policy Server of the Home Network domain. The Policy Server could in turn use the policy control interface to manipulate the corresponding node, e.g. the GGSN, to act accordingly. The Policy Server could also inform other networks involved in the service provisioning 25 using the policy control framework. For example, the

Policy Server in the Home Network domain could inform the Policy Server in the WLAN of the new access rate limit, so that the WLAN Policy Server could adjust local admission control mechanism accordingly.

5 Fig. 9 shows an example implementation of the message used between the Home Network Authorizer (103) and the Policy Server. The message starts with the Operation field (901). This field indicates the operation to be taken by the Policy Server. Possible value could be:

10       Install   ::= 0x01;

          Remove   ::= 0x02;

          Update   ::= 0x03;

When Home Network Authorizer (103) received a new service session request from the Mobile Terminal (101), it 15 would use value "Install" in the Operation field (901). When Mobile Terminal (101) terminates a service session, the Home Network Authorizer (103) would use "Remove" value in the Operation field (901). The "Update" value would be used when the service request from the Mobile Terminal 20 (101) is regarding an active service session. It is obvious to anyone skilled in the art that other types of value could be used in real implementation.

Second field is the MT\_ID field (902). This field contains the identifier of the Mobile Terminal (101). For 25 example, it could be the IMSI of the mobile user.

Third field is the MT\_Location field (903). This field would be used by the Policy Server to retrieve location based service policy, e.g. provide double access rate when the terminal is a certain WLAN. This field 5 could contain, for example, the WLAN identifier from the WLAN\_ID field (309) in the MT\_Request\_A message (202A).

The next field is the MT\_Service field (904). This field indicates what kind of service is accessed by the Mobile Terminal (101). It could also contain the service 10 session information. An example of the content in this field could be the APN plus the session identifier.

The next field is the Tunnel\_Setting field (905). This field indicates the tunnel setting used by the Mobile Terminal (101) in the WLAN. The contents of this field 15 are the tunnel type followed the tunnel end point address, port number, etc. The exact format is tunnel type specific. The tunnel types used are the same as those defined for the Tunnel\_Request field (308) field in the MT\_Request\_A message (202A).

20 The last field of the message is the MT\_Address field (906). This field contains the address used by the Mobile Terminal (101) in the WLAN. This could be used by the Policy Server to set the filtering rules for accessing the service.

25 It is obvious to anyone skilled in the art that in

real implementation, the message fields need not follow the exact order as described above. Each field could also include extra information not described in the example in actual implementation.

5

#### INDUSTRIAL APPLICABILITY

The present invention provides a way for managing the address allocation of the terminal in WLAN inter-working. When it deployed, the mobile terminal could be allocated an address based on the service it requested and its subscription information. The address management could be carried out without requiring access to the local resources. The invention also provides a method for control the tunnel setup in the WLAN inter-working. With it, the mobile terminal could support either network based or client based tunnel setup together with the service authorization. This invention also provides a method for inter-working with the policy control framework. Using the interface provided, the service authorization, address allocation, and tunnel setting information could be propagated to the policy servers, and proper action could be taken to better deliver the service to the terminal. With all the methods, the address management, tunnel setup, and service authorization could be accomplished within one roundtrip message exchange between the terminal and its

home domain server. Thus, precious signalling time and bandwidth could be saved.